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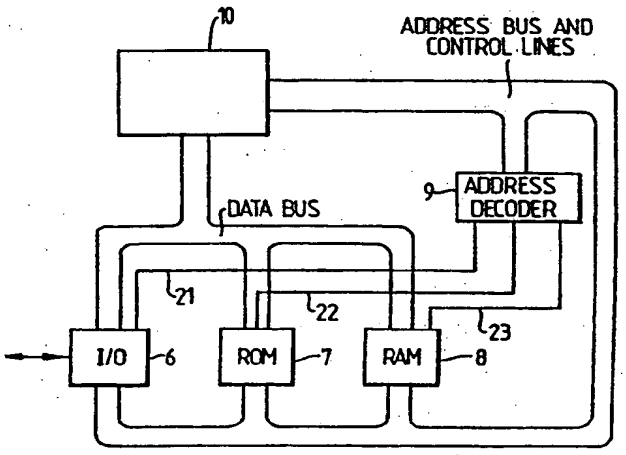
(54) Processing device and method.

(57) A device (5) for attachment to a main processor (2) and a method for their operation are disclosed. The device comprises a store (7) for storing secure data essential for the correct action of a computer program, the store being arranged such that the secure data is unreadable by a user, and the secure data defining at least in part one or more steps of the computer program. A subsidiary processor (10) is provided for carrying out the or each step defined by the secure data; and interface means (6) enables data to be received by the device (5) from the main processor (2) and to be transferred from the device (5) to the main processor (2) whereby the device and the main processor together enable the computer program to run.

In use, the main processor (2) determines when a step in the computer program is to be found in the device (5) and passes data and a program counter identifying the next step to the device (5). The subsidiary processor (10) carries out the step or steps indicated by the program counter on the transferred data; and passes resultant data and a new program counter to the main processor (2), the new program counter indicating the next step or steps of the computer program to be carried out by the main processor.



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52/2285/02

PROCESSING DEVICE AND METHOD

The invention relates to the processing of computer programs and in particular the protection of software packages from unlicensed duplication.

It is becoming increasingly important to prevent the unlicensed duplication of commercial software by both amateurs and professional copiers. Most software is sold stored on disc or cassette media and various attempts have been made in the past to prevent unauthorised copying of programs stored in this way. However, expert users have devised counters to most of these protective methods and there is therefore a need for a new method for protecting software.

EP-A-0084441 discloses the use of an auxiliary component which contains a unique, fixed serial number. A computer program is fully stored within a main processor which transfers data it generates to the auxiliary unit where the data is compared with a code. If a match if found between the incoming stream of data and the code, further running of the program is blocked. The unique serial number is then transmitted to the main processor and if the serial number matches an expected serial number, the program recommences running. This system does not solve the problem outlined above since the user can monitor the data transferred between the auxiliary unit and the main processor and determine the unique serial number stored in the auxiliary unit.

In accordance with one aspect of the present invention, a device for attachment to a main processor comprises at least a store for storing secure data essential for the correct action of a computer program, the store being arranged such that the secure data is unreadable by a user, and the secure data defining at least in part one or more steps of the computer program;

a subsidiary processor for carrying out the or each step defined by the secure data; and interface means for enabling data to be received by the device from the main processor and to be transferred from the device to the main processor whereby the device and the main processor together enable the computer program to run.

This invention avoids the problems of the prior art by arranging for at least one step of the computer program to be permanently stored in the device. This part of the program is never transferred to the main processor and thus cannot be read by the user.

Typically, the main processor will comprise a microcomputer and in general a conventional storage medium such as a magnetic disc or tape will store those steps of the computer program which are carried out by the main processor.

Preferably, the steps of the computer program which are defined by the secure data represent a key part of the software. For example, in a computer program which can be arranged into the so called "top down" form part of the top end of the program could be stored in the device. In this example overall control of the computer program may be provided by the device. In addition, or alternatively, the device store could store secure data defining look-up tables or data tables. Other parts of the computer program could define mathematical routines, an initialisation routine, or other data processing routines such as routines for rotating numbers, bit testing, or bit alteration. The advantage of placing a key part of the software in the device store is that it becomes very difficult for a user who simply observes the overall operation of the computer program to determine the steps which are carried out within the device.

The device store may comprise a PROM, EPROM, or RAM or may be provided by a battery operated RAM. In this

case, the battery will also be provided as part of the device. The interface means may be provided by a conventional serial or parallel link such as a UART.

In many cases, it will be very difficult for a user to determine what the secure data is but in some cases it may be possible by observing the data which is transferred between the main processor and the device to obtain an indication of the secure data. To make this more difficult, it is therefore preferable if the device further comprises decoding means for receiving from the main processor data and an associated program counter, the decoding means being arranged to select particular steps of the computer program defined by the secure data in accordance with the program counter.

In one important arrangement suitable for use with all the examples mentioned above, a serial number may be associated with the device, the decoding means modifying data which it transfers to the main processor in accordance with an algorithm stored in the device, using the serial number. In this arrangement, the main processor will be arranged to decode the transferred data by using the same serial number and an appropriate algorithm. An example of such an algorithm is a logical operation such as an Exclusive-OR operation or like encoding operation.

The advantage of using a serial number is that the device and associated software which is loaded into the main processor can be initialised with the same serial number so that the associated software will only work with the particular device. If the associated software is then duplicated it will not operate with another device having a different serial number. Conversely, if the device is used on associated software derived from another source, it will also not work because the serial numbers will not be the same.

The serial number may be provided in the device when the device is manufactured or it could be initialised when the device is sold by a dealer to a user.

It is important that the secure data is unreadable and this may be achieved if the various parts of the device are mounted in a secure container to prevent the store from being analysed. This security can be achieved by immersing the components in epoxy resin or a multilayer potting material which is preferably acid resistant and heat resistant up to about 150°C. This will mean that if someone tries to gain access to the store it is very likely that the store will be damaged when attempts are made to remove the potting material.

Another method for making the container secure is to use a battery operated RAM instead of the more usual EPROM and to arrange the circuit containing the RAM and battery in such a way that it will be broken when anyone tries to gain access to the container. Once the circuit is broken the contents of the RAM will be irretrievably lost. In one such arrangement, the components of the device may be submerged in potting material such as epoxy resin and the wire connecting the RAM and the battery may be wrapped around the epoxy resin mass, the wrapped product then being itself submerged in potting material and surrounded in a metal case. This arrangement makes it very likely that any attempt to remove the epoxy resin will also sever the wire.

Conveniently, the container comprises a hardened steel case.

In addition, or alternatively, conventional sensors may be provided within the container to sense when attempts are being made to open the container, the sensors causing power to the RAM to be turned off.

In a further arrangement, metal filings may be provided in the potting material to provided additional

security against radiation methods of viewing the device store.

In another particularly preferable arrangement the components of the device are incorporated on a semiconductor chip held in a thin card such as a so-called "smart" card which is a card having dimensions similar to a credit card.

In accordance with a second aspect of the present invention, a method for operating a main processor connected to a device in accordance with the first aspect of the invention comprises determining when a step in the computer program is to be found in the device; passing data and a program counter identifying the next step to the device; causing the subsidiary processor to carry out the step or steps indicated by the program counter on the transferred data; and passing resultant data and a new program counter to the main processor, the new program counter indicating the next step or steps of the computer program to be carried out by the main processor.

To make it more difficult for a user to understand the operation of the overall computer program, the data transferred between the device and the main processor may include dummy data which is ignored by the respective one of the main and subsidiary processors when carrying out the indicated step or steps of the computer program and preferably the dummy data is changed between each transfer. This makes it even more confusing for an observer.

As has previously been mentioned, the data transferred between the device and the main processor may be coded by using an algorithm based on a serial number unique to the device in the main processor to provide added security.

There are many situations in which the invention may be applied. For example, in any data transfer system,

for example satellite communication as well as more common applications where duplication of a computer program is to be prevented. This latter aspect allows not only the sale of programs to be controlled but also the licencing of programs.

An example of a device and a method for its operation in accordance with the present invention will now be described with reference to the accompanying drawings, in which:-

Figure 1 is a block diagram of the device connected to a main processor;

Figure 2 is an enlarged block diagram of the device; and,

Figure 3 is a block diagram of a typical top down program structure.

Figure 1 illustrates a main processor unit 1 which may comprise a conventional microcomputer including a central processing unit 2 at least one store 3 and an interface 4. Data to be processed may be input into the main processor 1 in any conventional way via another interface (not shown) and the data may originate from a manual data input device such as a keyboard or some other data supply such as a disc store.

The main processor unit 1 is connected to an auxiliary device 5 via the interface unit 4. The device 5 is shown in more detail in Figure 2 and comprises a serial or parallel input/output device 6 connected to the unit 4 of the main processor unit 1; a ROM 7; and a RAM 8. In addition, the device 5 includes an address decoder 9 and a microprocessor 10. All the elements 6-10 of the device can be fabricated on a single chip such as Motorola 6801. The microprocessor 10 is connected via a data bus with the input/output device 6, the ROM 7 and the RAM 8 and via an address bus and control lines with the address decoder 9 and the devices 6-8. The address

decoder 9 is connected by address lines 21, 22, 23 to the elements 6, 7, 8 respectively in order to control which of the elements is active. The devices 6-10 can be powered remotely or with an internal power source such as a battery (not shown) forming part of the device 5.

In one example, the device 5 is housed in a container 11 made from hardened steel to prevent access being obtained to the components within it.

In addition, the components may be embedded in a suitable potting material such as epoxy resin which will cause the integrated circuits forming the various components to break if the potting material is chipped off or sawn. It is therefore virtually impossible to remove the potting material without destroying the integrated circuits.

In another arrangement the components forming the device 5 may be incorporated into a thin card such as a "smart" card for ease of manufacture and use. A suitable card is manufactured by Flonic of France. In practice, it is very difficult to obtain information from the card such as details of the contents of the memories 7, 8.

Figure 3 illustrates diagrammatically the structure of a typical top-down program in block diagram form. The program comprises a main organisational routine 12 which oversees the operation of the program. Each step in the main routine 12 causes appropriate ones of an input driver 13, mathematical processor 14, a data processor 15, and other routines such as indicated at 16 to be accessed. These sections of the program themselves access certain subroutines 17, 18 and look-up tables 19. For simplicity only a small number of subroutines and other routines are indicated. Furthermore, it should be understood that many computer programs can be reorganised into the top-down form.

The essence of the invention lies in taking a key part of a particular computer program such as the organisational routine 12 and/or the data processor 15 and storing this in the ROM 7 of the device 5. The remainder of the program including the look-up tables 19, the mathematical processor 14 and the subroutines 17, 18 are stored in the store 3 of the main processor unit 1. The computer program will not operate without the part stored in the ROM 7. In other examples further key parts of the computer program are stored in the ROM 7 and preferably only the subroutines are stored in the main processor unit 1.

During manufacture the secure data (eg. the data processor steps of a computer program) is loaded into the ROM 7. The remainder of the software may be loaded onto disc which is accessible to third parties who may read its contents. The contents will, however, be worthless without the (unreadable) contents of the ROM 7.

In use, the main processor 2 carries out steps of the computer program stored its memory until it determines that the next step in the program is not stored in its memory but is stored in the ROM 7. At this stage, data necessary for the next step or steps to be carried out together with a program counter is transferred from the main processor 2 via the interface 4 to the I/O device 6. The address decoder routes the data in a conventional manner to the RAM 8. The processor 10 determines from the program counter transferred the next step to be carried out and then accesses from the ROM (under control of the address decoder 9) the step or steps indicated by the program counter and carries out these steps on the transferred data. When the step or steps selected have been completed the resultant data together with a new program counter is passed via the I/O device 6 and interface 4 back to the main processor 2.

The main processor 2 then determines from the program counter transferred the next step in the program to be carried out. This process may be repeated a number of times depending upon how often the steps stored in the ROM 7 must be used.

Additional security may be provided by assigning a unique serial number to the software stored in the ROM 7 and the software stored in the store 3. This serial number is then used to code the data transferred between the main processor 2 and the processor 10. An example of such a serial number is:

10010011.

This serial number is loaded in the store 3 and has been stored in the ROM 7 during manufacture of the device 5. Subsequently, when data is transferred, for example from the main processor 2 to the processor 10, it is firstly coded using a predetermined algorithm based on the serial number. An example of such an algorithm is the Exclusive-OR operation. Thus, if the data to be transferred is:

00000010

then the resultant data transferred after the exclusive-OR operation will be:

10010001

The processor 10 carries out a reverse operation to regenerate the original data so that the original program counter can be determined. When the processor 10 has carried out the required steps the output data and the new program counter will be coded in a similar way using

the exclusive-OR operation and the same serial number and then transferred to the main processor 2 which will carry out the reverse operation to regenerate the original data.

Alternatively, or in addition, dummy data may be transmitted between the main processor unit 1 and the device 5 to increase security against monitoring of the data transferred.

CLAIMS

1. A device (5) for attachment to a main processor (2), the device comprising at least a store (7) for storing secure data essential for the correct action of a computer program, the store being arranged such that the secure data is unreadable by a user, and the secure data defining at least in part one or more steps of the computer program; a subsidiary processor (10) for carrying out the or each step defined by the secure data; and interface means (6) for enabling data to be received by the device (5) from the main processor (2) and to be transferred from the device (5) to the main processor (2) whereby the device and the main processor together enable the computer program to run.

2. A device according to claim 1, wherein the computer program can be arranged into a "top down" form, part of the top end of the program constituting the secure data which is stored.

3. A device according to any of the preceding claims, wherein the store (7) comprises a battery operated RAM.

4. A device according to any of the preceding claims, further comprising decoding means for receiving from the main processor data and an associated program counter, the decoding means being arranged to select particular steps of the computer program defined by the secure data in accordance with the program counter.

5. A device according to claim 4, wherein a serial number is associated with the device, the decoding means modifying data which it transfers to the main processor (2) in accordance with an algorithm stored in the device (5), using the serial number.

6. A device according to claim 5, wherein the algorithm is an exclusive-OR operation.

7. A device according to any of the preceding claims wherein at least the store (7) and secure data and the

subsidiary processor (10) are contained in a secure container.

8. A method for operating a main processor (2) connected to a device (5) according to any of the preceding claims, the method comprising determining when a step in the computer program is to be found in the device (5); passing data and a program counter identifying the next step to the device (5); causing the subsidiary processor (10) to carry out the step or steps indicated by the program counter on the transferred data; and passing resultant data and a new program counter to the main processor (2), the new program counter indicating the next step or steps of the computer program to be carried out by the main processor.

9 A method according to claim 8, wherein the data transferred between the device (5) and the main processor (2) includes dummy data.

Fig.1.

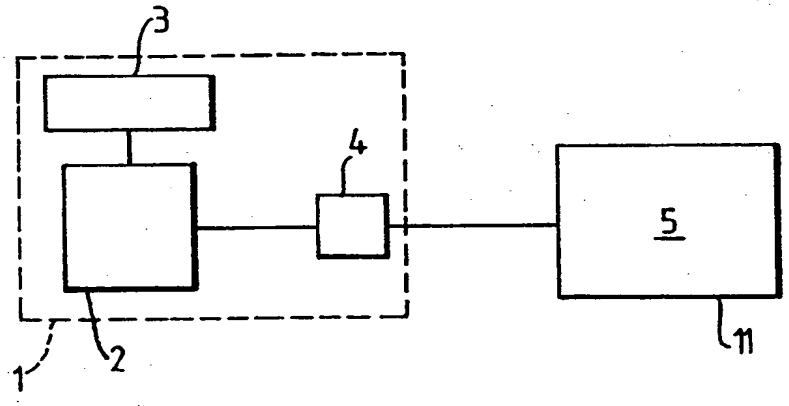

3
4
5
1
2
11

Fig.2.

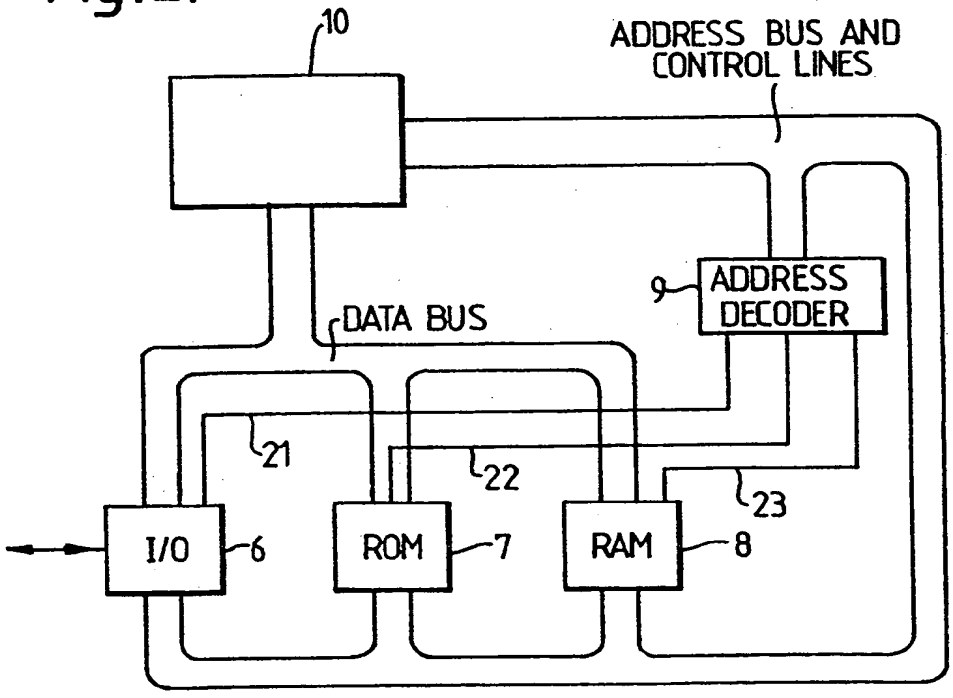
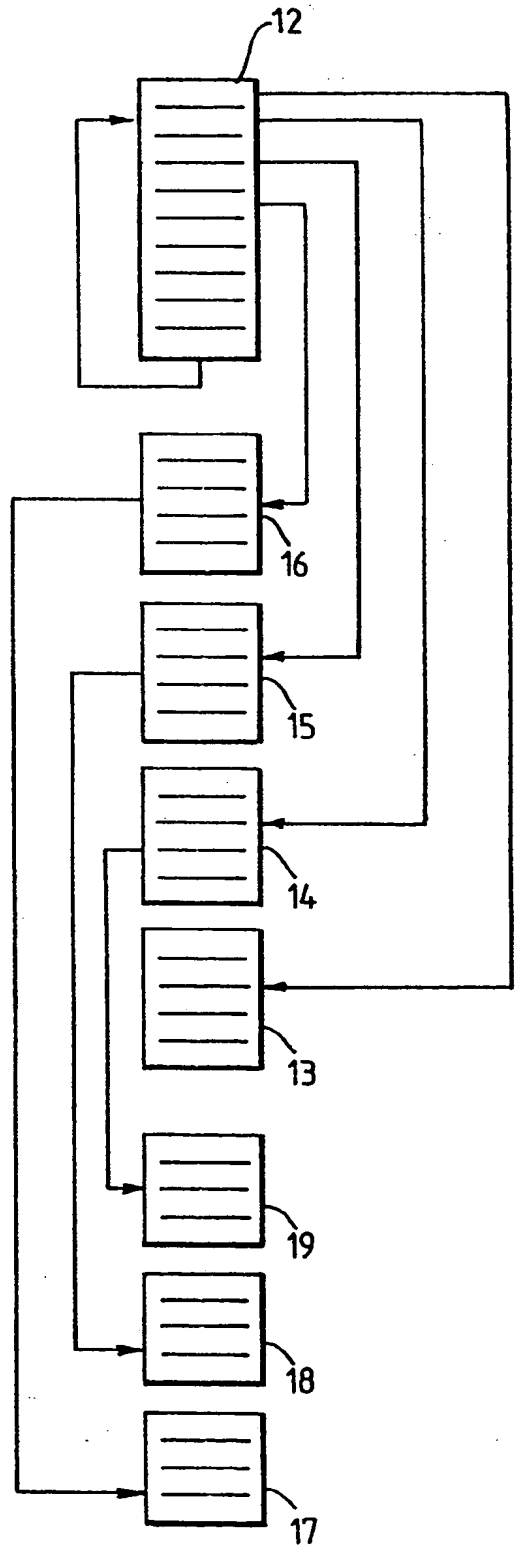

10
ADDRESS BUS AND CONTROL LINES
9
ADDRESS DECODER
DATA BUS
21
22
23
I/O
6
ROM
7
RAM
8

Fig.3.



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EUROPEAN SEARCH REPORT

Application number
EP 85 30 6524

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A,D	EP-A-0 084 441 (ROGERS) * Page 3, line 23 - page 4, line 12; page 8, lines 2-15; page 5, lines 20-24 *	1,5,8	G 06 F 1/00 G 06 F 12/14
A	DE-A-3 023 427 (EHRAT) * Page 8, lines 26-30; page 9, line 8 - page 12, line 5 *	3,6,7	
P,A	EP-A-0 128 672 (GALE) * Whole document *	1,3,7,8	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

G 06 F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	22-11-1985	LEPEE W.

CATEGORY OF CITED DOCUMENTS

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